# Study of $b$-tagging performance in Run IIA

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## 1 Introduction

Most of Higgs boson searches at Tevatron rely on the analyses with $b$-tagging. After $b$-tagging huge QCD background from light jets is significantly reduced while final states with $b$ and $c$-jets become main background to Higgs channels. To estimate each kind of background after applying $b$-tagging technique properly one needs to know main characteristics of the $b$-tagging algorithm which are $b$-tagging efficiency and efficiency to tag a light jet (or mis-tagging rate).

We performed detailed studies of b-tagging efficiency and mis-tagging rates for the Run IIA tracking system. The Counting Signed Impact Parameter (CSIP) $b$-tagging algorithm developed for Run IIA has been used to estimate the b-tagging performance of the DØ detector in the present state and after irradiation of silicon tracker. Our studies are based on full GEANT simulation of signal and background events with consequent reconstruction of physical objects.

The irradiation of the silicon detector might lead to a significant degradation of the $b$-tagging capabilities of the DØ experiment. Irradiation affects the innermost layers in the first place leading to lower signal-to-noise ratio in detectors or even to the total loss of the innermost layer. $b$-tagging performance is defined by impact parameter resolution to a large extent (which depends on the closest to an interaction measurement) and on the tracking capabilities of the experiment. So, not only the impact parameter of tracks will become worse but, since we loose one stereo measurement per track, it will lead to the degradation of the tracking efficiency in jets and high-$p_T$ leptons as well.

## 2 Samples used for the $b$-tagging efficiency and mis-tagging rate measurements

For $b$-tagging efficiency measurement we used 3500 WH events with zero minimum bias events overlaid. Signal events simulated requiring $W$-decay to lepton and neutrino and Higgs boson decay to $b\bar{b}$. Higgs mass was chosen to be 120 GeV. For mis-tagging rate we used 10500 events with $Z$-boson decays into light quarks ($u$, $d$ or $s$) with zero minimum bias events. In order to avoid statistical effects, we have used exactly the same set of events to estimate the relative performance of $b$-tagging before and after SMT irradiation.

Irradition of the silicon tracker was assumed to lead to the total loss of the innermost silicon layer (L1). All hits from the L1 were removed out of list of hits and tracks were reconstructed using the rest of the hits.

Reconstruction was made by using latest version of DØ tracking reconstruction software. The new tracking has been proven by the DØ studies to have higher tracking efficiency in jets at lower fake track rate compared to our present tracking version. The list of dead silicon devices and dead channels as well as noisy channels is known from Run IIA calibration runs. Hits from all of them

were automatically excluded during the full simulation and reconstruction for both cases of $b$-tagging performance studies, present SMT and SMT after irradiation.

# 3 CSIP performance in Run IIA

Measurement of $b$-tagging efficiency is done by using Monte Carlo information about origin of jets. Jet flavor was determined by matching of the reconstructed jet to the quark direction within a cone $\Delta R = \sqrt{\Delta\phi^2_{jet,q} + \Delta\eta^2_{jet,q}} < 0.3$. Jet is called a $b$-jet if it contains a $b$-quark inside the cone $\Delta R$. It is called a $c$-jet if the heaviest quark inside this cone was $c$-quark. Light jets are all jets which have no $b$ or $c$-quarks in a cone $\Delta R$.

Efficiency is determined as ratio of the number of tagged $b$-jets to the total number of $b$-jets. $b$-tagging efficiency per jet as a function of $E_T$ of jet and $\eta$ of jet is shown in Fig. 1 for two cases, standard SMT and SMT after L1 is lost.

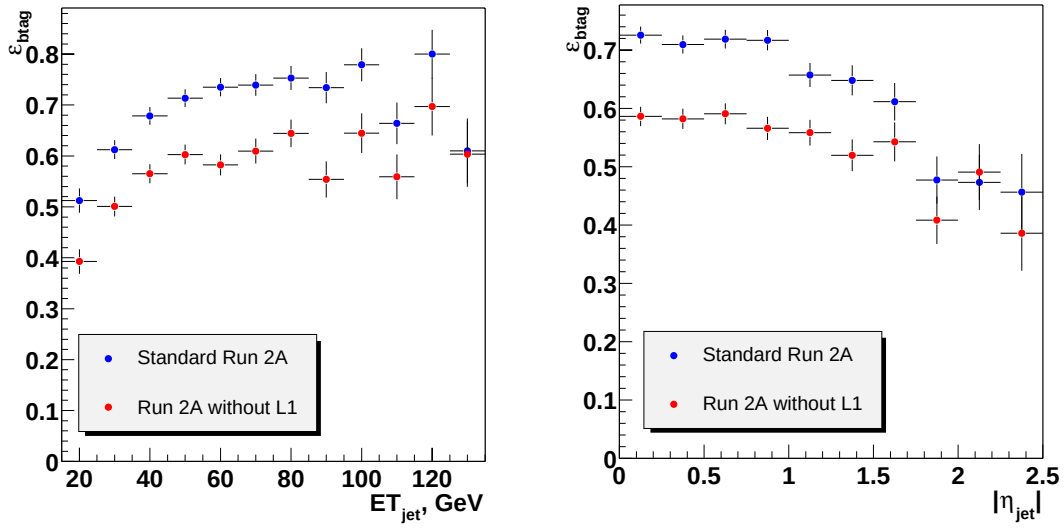


Figure 1: $b$-tagging efficiency before and after SMT irradiation.

Significant degradation of $b$-tagging efficiency per jet in the whole $E_T$ region and in the central $\eta$ region is observed after irradiation. In the forward $\eta$-region the tracking relies heavily on the F- and H-disks whose performance was not degraded. Therefore relative drop in efficiency in the forward region is less significant compared to the central $\eta$ region.

We also estimated the mis-tagging rate using light jets. We observe increase of mistagging rate (Fig. 2). Fig. 3 shows mis-tagging rate vs $b$-tagging efficiency for three algorithm working points (track $p_T$ cut 0.5, 1, and 1.5 GeV). The performance curves show that at fixed $b$-tagging rate of 57% we will have almost 3 times larger mis-tagging rate compared to the present Run IIA performance.

The overall $b$-tagging performance is summarized in Table 1. The relative degradation in $b$-tagging efficiency per jet is 18% and the mis-tagging rate increase is 12%. The relative degradation in double $b$-tagging efficiency is 40%.

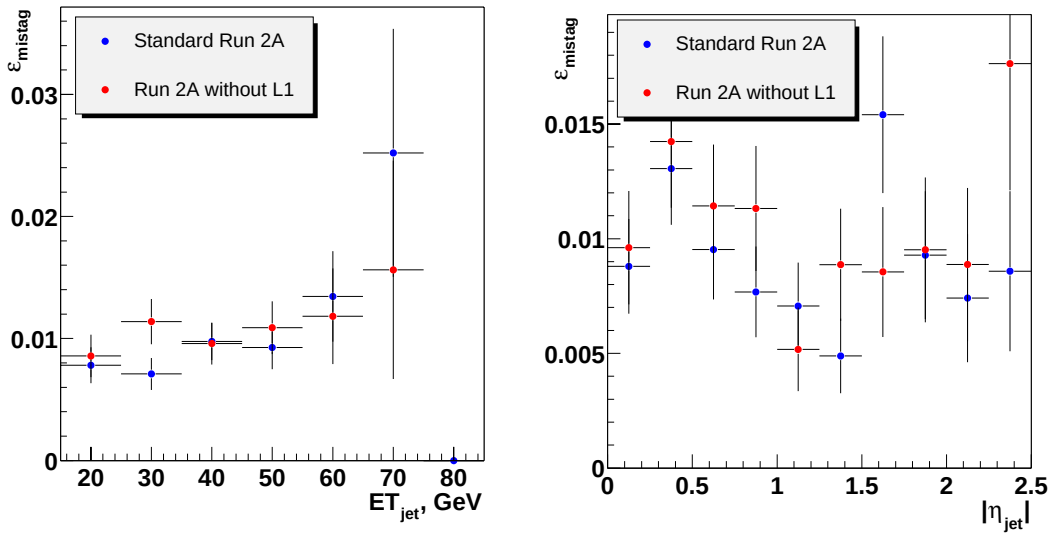


Figure 2: Mis-tagging rate before and after SMT irradiation.

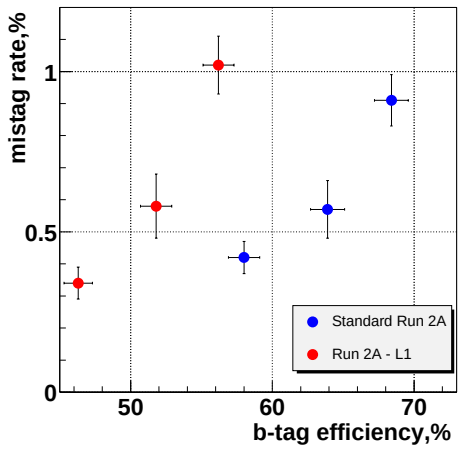


Figure 3: Mis-tagging rate vs $b$-tagging efficiency before and after SMT irradiation.

| | Run IIA | Run IIA-L1 |
|---|---|---|
| $b$-tagging efficiency per jet | 68.4±0.1% | 56.2±0.1% |
| mis-tagging rate per jet | 0.91±0.08% | 1.02±0.09% |
| P($n \geq 1$) in WH(bb) | 70.7±1.4% | 59.2±1.3% |
| P($n \geq 2$) in WH(bb) | 23.4±0.8% | 14.1±0.6% |
| P($n \geq 1$) in Z(uds) | 1.41±0.12% | 1.47±0.13% |

Table 1: The overall $b$-tagging performance before and after SMT irradiation.